As demand for healthcare continues to grow, medical practitioners are turning to mobile-monitoring, therapeutic, and diagnostic devices that can improve the quality and efficacy of medical care. As a result, medical devices have been downsized, from bulky to portable to handheld to wearable. Device manufacturers are selling their products to increasingly tech-savvy clinicians and patients who are accustomed to using myriad portable and handheld electronic devices. Having experienced the high functionality of smartphones, for example, consumers expect the same from medical devices with small form factors.

In some cases, these medical devices and related communications devices have become part of remote medical treatment systems. For example, the practice of “telehealth” uses digital information and communication technologies, such as computers and mobile devices, to manage patients’ health and well-being. Early detection of symptoms or changes in physiology allows for preventative measures and earlier treatment, before a patient’s health deteriorates.

Wearable technologies and other small medical devices that provide continuous real-time feedback help make telehealth possible. Telehealth practitioners make use of online health information and remote patient communication facilitated by remote monitoring of health indicators, such as blood glucose, blood pressure, heart rhythm, pulse, and other vital signs, read via sensors attached to or worn by a patient. These miniaturized real-time medical monitoring devices can benefit patients with chronic and potentially life-threatening conditions, as well as their healthcare providers, who face mounting pressures to improve outcomes while reducing costs and hospital readmission rates.

LIGHTWEIGHT CIRCUITRY

Compact medical devices are made possible by lightweight circuitry that fits within tight spaces. Anyone who has packed a suitcase knows firsthand that the contents must bend or flex in order to maximize space and efficiency.

Among a number of proven technologies that have migrated from consumer electronics into medical devices, flexible circuits and flexible printed electronic solutions help designers optimize space in tightly packaged medical devices. Products such as insulin pumps, wearable patient monitoring devices, portable defibrillators, and CPAP machines (used to treat sleep and breathing disorders) typically employ flex circuits.

Unlike conventional 2D circuits, flexible printed circuits and printed electronics occupy three dimensions, so they can be bent around packaging and even be folded over to fit in miniaturized device enclosures. There are several other advantages. Flexible substrates with single-sided, double-sided, and multi-layer circuitry are ideal for high performance signal and power connections at an economical applied cost. Flex products can also be mounted in through-hole, surface mount, and press-fit configurations.

Flex circuits allow designers to make electronic interconnection simpler and more reliable. Unlike hard board materials containing woven glass fibers that tend to result in signal loss, the materials used in flex circuits, such as polyimide, help maintain signal and power integrity. Polyimide dissipates heat quicker, so the flex circuit requires less cooling. Additionally, flex materials closely match thermal expansion rates, which make them more reliable in hot and cold temperature extremes and the temperature fluctuations found in mobile healthcare applications.

Medical device miniaturization requires producers to adapt flex circuits for 3D packaging, tighter copper flex spacing, and smaller trace widths. As the device package size shrinks, the flex circuit must also shrink. Incorporating features like blind and buried vias can help retain flexibility as the device package size continues to decrease.

High-reliability flex circuits are excellent choices for small, lightweight designs with complex, high-density circuitry. Significantly thinner and lighter than traditional circuit boards, flex circuits make any product lighter, which contributes to improved patient mobility and comfort and, in many cases, cost savings.
BETTER PACKAGING

Flex circuits are also a potent tool for improving electronic packaging. A well-designed mechanical package that's consistent, mechanically sound, and promotes airflow may include a wide variety of electronic components, including connectors, transmitters, receivers, resistors, capacitors, etc. Those components must be contained in a tightly packed, electrically interconnected package. Flex circuits make that possible. Unlike rigid circuit boards, which only allow circuit traces in the X and Y planes, flex circuits allow designers to route circuits along curved surfaces and in multiple directions on any axis.

Designing an effective package is a collaborative process involving device designers and their suppliers. Flex circuit designs always contain tradeoffs in electrical and mechanical performance. Molex works with its customers on issues such as optimum routing of flex circuits in packages to optimize signal strength and mechanical integrity.

Those package designs may also include “rigid flex” circuits, which include both rigid and flexible substrates laminated together in a single structure. For example, there may be a section of the device with several electronic components — resistors, capacitors, connectors, processors — that is rigid, but a flexible electrical “tail” leads from the rigid section, eliminating the need for an interface connector.

NEXT-GEN FLEX CIRCUITS

Flex circuits used in medical devices will continue to shrink in size while providing better performance. One of the most promising developments in this area is the use of DuPont™ Pyralux® TK copper-clad laminate and bonding film systems, made from specially formulated Teflon fluoropolymer film and DuPont Kapton® polyimide film.

Pyralux TK allows developers to create multi-layer circuits that can be bent around a much tighter radius. It also allows faster data rates compared to standard polyimide flex assembly materials, producing lower overall insertion loss and less noise, all in a smaller mechanical footprint. These flexible, layered circuits target next-generation 12 and 25 Gbps device designs. Molex has worked with DuPont to develop the processing technology required to apply Pyralux TK to the company’s flexible circuits. The new circuits are already in use in some electronic devices.

As medical technology continues to expand, digital connectivity will bring opportunities for device designers to build new business models that help reduce healthcare costs. It’s clear that flexible circuits will play a key role in that process.